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**The intervention effect of local alcohol licensing policies on hospital admission and crime: a natural experiment using a novel Bayesian synthetic time-series method**

Frank de Vocht[1,2], Kate Tilling[1,2], Triantafyllos Pliakas[1,3], Colin Angus[1,4], Matt Egan[1,3], Alan Brennan[1,4], Rona Campbell[1,2], Matthew Hickman[1,2]

[1] NIHR School for Public Health Research

[2] School of Social and Community Medicine, University of Bristol, Bristol, UK

[3] Department of Health Services Research and Policy, London School of Hygiene and Tropical Medicine, London, UK.

[4] ScHARR, School of Health and Related Research, University of Sheffield, Sheffield, UK.

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## Online Supplementary Materials

**BAYESIAN STRUCTURAL TIME SERIES**

*The data used in these analyses are freely available from:*

*http://www.lape.org.uk/data.html*

*http://www.ons.gov.uk/peoplepopulationandcommunity/crimeandjustice/bulletins/crimeinenglandandwales/2015-07-16*

*http://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration*

*The statistical methodology is outlined in summary below*

Bayesian structural time-series model use a Bayesian state-space time-series model that includes one component of state as a linear regression on the predictors. It is described in detail here (1, 2), but in summary can be described by an 'observation equation' (Eq. 1), which links the observed data ($y_t$; *i.e.* the measured crime or hospital admission rates) with an unobserved latent state ($\alpha_t$), and a 'transition equation' (Eq. 2); the latter describing the evolution of $\alpha_t$ over time:

$$y_t = Z_t^T \alpha_t + \varepsilon_t \quad \text{(Eq. 1)}$$

$$\alpha_{t+1} = T_t \alpha_t + R_t \eta_t \quad \text{(Eq. 2)}$$

where $\varepsilon_t \sim \mathrm{N}(0, \sigma_t^2)$ and $\eta_t \sim N(0, Q_t)$, and both are independent of all other unknowns, $y_t$ is a scalar observation, $Z_t$ is an output vector, $T_t$ is the transition matrix, $R_t$ the control matrix, $\eta_t$ describes the system error with a state-diffusion matrix $Q_t$ ($R_t \eta_t$ allows the inclusion of seasonality in these analyses), and $\varepsilon_t$ is a scalar observation error with variance $\sigma_t$. The errors of different state-component models are assumed to be independent.

This framework includes a regression component which enables the construction of a synthetic time series based on combinations of the control units/areas (*i.e.* the counterfactual). A generalisation of the local linear trend model with the slope having stationary random walk is used, and can be described by equations 3 and 4:

$$\mu_{t+1} = \mu_t + \delta_t + \eta_{\mu,t} \quad \text{(Eq. 3)}$$

$$\delta_{t+1} = D + \rho(\delta_t - D) + \eta_{\gamma,t} \quad \text{(Eq. 4)}$$

Where $\mu_t$ is the value of the trend at time t and $\delta_t$ the slope at time t, $\eta_{\mu,t} \sim N(0, \sigma_\mu^2)$, and $\eta_{\delta,t} \sim N(0, \sigma_\delta^2)$. The two components of $\eta$ are independent and $D$ signifies the long-term slope. $|\rho|<1$ represents the learning rate at which the local trend is updated.

A spike-and-slab prior is placed on the regression coefficients and the model averages over the pool of control areas to construct the 'synthetic control' (2, 3). The "spike" determines the probability a control area has a non-zero coefficient (i.e. being included in the model) based on independent Bernoulli distributions, and the "slab" is a weakly informative Gaussian prior with a large variance.

As a result, the posterior predictive density is a joint distribution over all counterfactual data points rather than a collection of pointwise univariate distribution to ensure a correct serial structure (19).

To account for seasonal differences (*i.e* here we have quarterly data), a seasonal component is added, and is described by equation 5:

$$\Upsilon_{t+1} = -\sum_{s=0}^{S-2} \Upsilon_{t-s} + \eta_{\Upsilon,t} \quad \text{(Eq. 5)}$$

Where $S$ is the number of seasons (*i.e.* 4) and $\Upsilon_t$ denotes their joint distribution to the observed $\gamma_t$. The mean of $\Upsilon_t$ over the four seasons is zero.

Prior distributions for the variance are set as Gamma distributions with expectation a/b, and for the seasonal and local linear trend models the incremental error in the state are *a priori* assumed to be small and set to $\frac{1}{\sigma^2} \sim G(10^{-2}, 10^{-2} s_y^2)$, where $s_y^2 = \sum_t (y_t - \bar{y})/(n-1)$ . Posterior simulation is done using a Gibbs sampler and Kalman filter o simulate from a Markov chain with a stationary distribution (for model parameters θ) $p(\theta, \alpha | Y_{1:n})$, and the posterior incremental effect is described by $p(\tilde{Y}_{n+1:m} | Y_{1:n}, X_{1:m})$, where $\tilde{y}_{n+1}, \ldots, \tilde{y}_m$ describe the counterfactual response.

The posterior distribution of the counterfactual time series post-intervention can then be computed based on the pre-intervention time-series data from all areas and the weighted post-intervention time series of the control areas, and by subtracting the estimated trends in the counterfactual 'synthetic control area' from the observed post-intervention data at each point in time semiparametric Bayesian posterior distribution for the causal effect of the intervention is obtained.

**References**


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## MARKOV CHAIN MONTE CARLO DIAGNOSTICS

### Table S1a . Diagnostic test statistics main analyses alcohol-related hospital admission rates

| | Geweke test final state (stationary) (Z-value) | Raftery diagnostic final state stationary (I) | Heidel diagnostic (stationary) P-value | Heidel diagnostic (Halfwidth) | Relative* absolute mean (max) 1-step prediction errors | Durbin Watson 1 step prediction errors (P-value) |
|---|---|---|---|---|---|---|
| **Alcohol-related hospital admissions** | | | | | | |
| Kingston-upon-Thames | 0.528 | 2.120 | 0.613 | 0.340/113.78 | 1.5% (6.9%) | 0.203 |
| Enfield | 0.599 | 0.964 | 0.085 | 0.895 / 156.986 | 1.9% (8.4%) | 0.204 |
| Derby | -0.056 | 0.962 | 0.734 | 0.878 / 210.597 | 1.6% (5.7%) | 0.201 |
| Southwark | 1.315 | 0.966 | 0.066 | 0.783/153.91 | 1.8% (7.2%) | 0.195 |
| North Tyneside | -0.740 | 0.954 | 0.366 | 0.943 / 241.36 | 1.5% (6.7%) | 0.189 |

*: relative to average alcohol-related hospital admission rate prior to intervention

**Table S1b. Diagnostic test statistics main analyses alcohol-related reported violent crime rates**

| | Geweke test final state (stationary) (Z-value) | **Raftery diagnostic final state stationary (I)** | Heidel diagnostic (stationary) P-value | Heidel diagnostic (Halfwidth) | Relative* absolute mean (max) 1-step prediction errors | Durbin Watson 1 step prediction errors (P-value) |
|---|---|---|---|---|---|---|
| **Alcohol-related violent crimes** | | | | | | |
| Kingston-upon-Thames | -0.852 | 0.951 | 0.926 | 0.0100/4.609 | 0.7% (2.9%) | 0.196 |
| Enfield** | 1.889 | 0.951 | 0.063 | 0.008/4.547 | 0.7% (2.6%) | 0.203 |
| Derby | -0.000 | 1.97 | 0.365 | 0.035/6.739 | 1.5% (6.7%) | 0.188 |
| Southwark | -1.121 | 0.954 | 0.848 | 0.050/8.722 | 1.7% (7.5%) | 0.179 |
| North Tyneside | -0.680 | 0.953 | 0.600 | 0.014/2.580 | 2.0% (9.0%) | 0.200 |

*: relative to average alcohol-related hospital admission rate prior to intervention. **: MCMC chain of 150,000 to satisfy all criteria

**Table S1c. Diagnostic test statistics main analyses alcohol-related reported violent sexual crime rates**

| | Geweke test final state (stationary) (Z-value) | **Raftery diagnostic final state stationary (I)** | Heidel diagnostic (stationary) P-value | Heidel diagnostic (Halfwidth) | Relative* absolute mean 1-step prediction errors | Durbin Watson 1 step prediction errors (P-value) |
|---|---|---|---|---|---|---|
| **Alcohol-related violent crimes** | | | | | | |
| Kingston-upon-Thames | -0.501 | 0.97 | 0.87 | 0.001 /0.123 | 3.7% | 0.189 |
| Enfield | 1.378 | 0.96 | 0.07 | 0.001/0.134 | 2.1% | 0.197 |
| Derby** | 1.585 | 0.97 | 0.13 | 0.001/0.205 | 2.2% | 0.213 |
| Southwark | 1.378 | 0.96 | 0.37 | 0.001/0.210 | 1.5% | 0.217 |
| North Tyneside | -0.731 | 0.95 | 0.751 | 0.0003/0.073 | 2.4% | 0.507 |

***:** relative to average alcohol-related hospital admission rate prior to intervention.

**Table S1d. Diagnostic test statistics main analyses alcohol-related reported public order offenses**

| | Geweke test final state (stationary) (Z-value) | **Raftery diagnostic final state stationary (I)** | Heidel diagnostic (stationary) P-value | Heidel diagnostic (Halfwidth) | Relative* absolute mean (max) 1-step prediction errors | Durbin Watson 1 step prediction errors (P-value) |
|---|---|---|---|---|---|---|
| **Alcohol-related violent crimes** | | | | | | |
| Kingston-upon-Thames | 0.514 | 0.96 | 0.078 | 0.021/1.667 | 3.6% | 0.191 |
| Enfield | -0.014 | 3.02 | 0.505 | 0.015/2.174 | 2.3% | 0.207 |
| Derby | 0.811 | 0.95 | 0.167 | 0.0118/2.725 | 1.4% | 0.198 |
| Southwark | -0.267 | 0.98 | 0.520 | 0.052/5.201 | 2.9% | 0.199 |
| North Tyneside | 1.247 | 0.96 | 0.180 | 0.0228/2.474 | 2.7% | 0.162 |

***:** relative to average alcohol-related hospital admission rate prior to intervention.

**GRAPHICAL REPRESENTATIONS OF MODELLED AND MEASURED TIME SERIES IN INTERVENTION AREAS.**

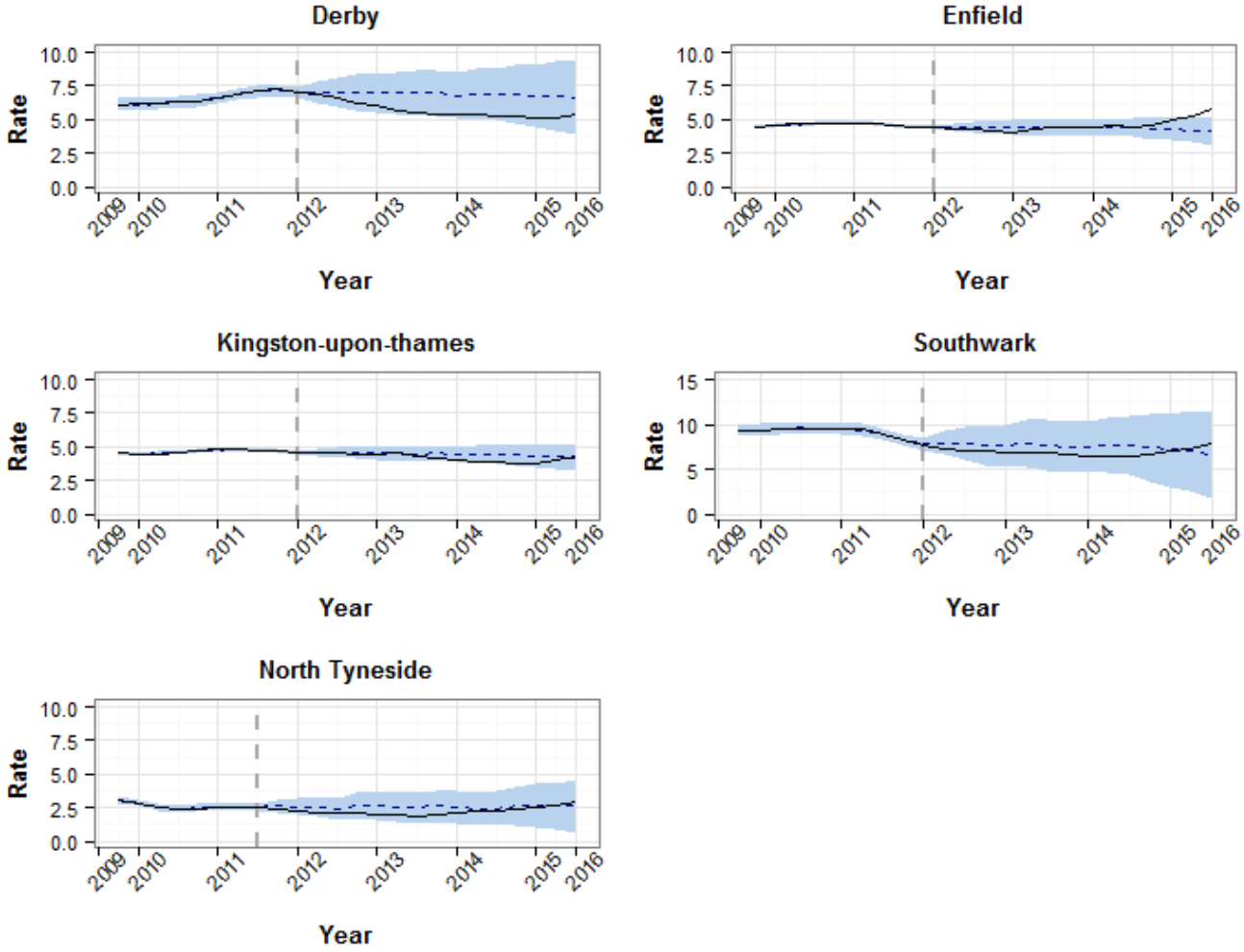


**Figure S1a. Measured (solid line) and modelled, synthetic (dotted line) time series for alcohol-related reported violent crime rates in the areas with the intervention. Blue areas represent 95% Bayesian Credible Intervals.**

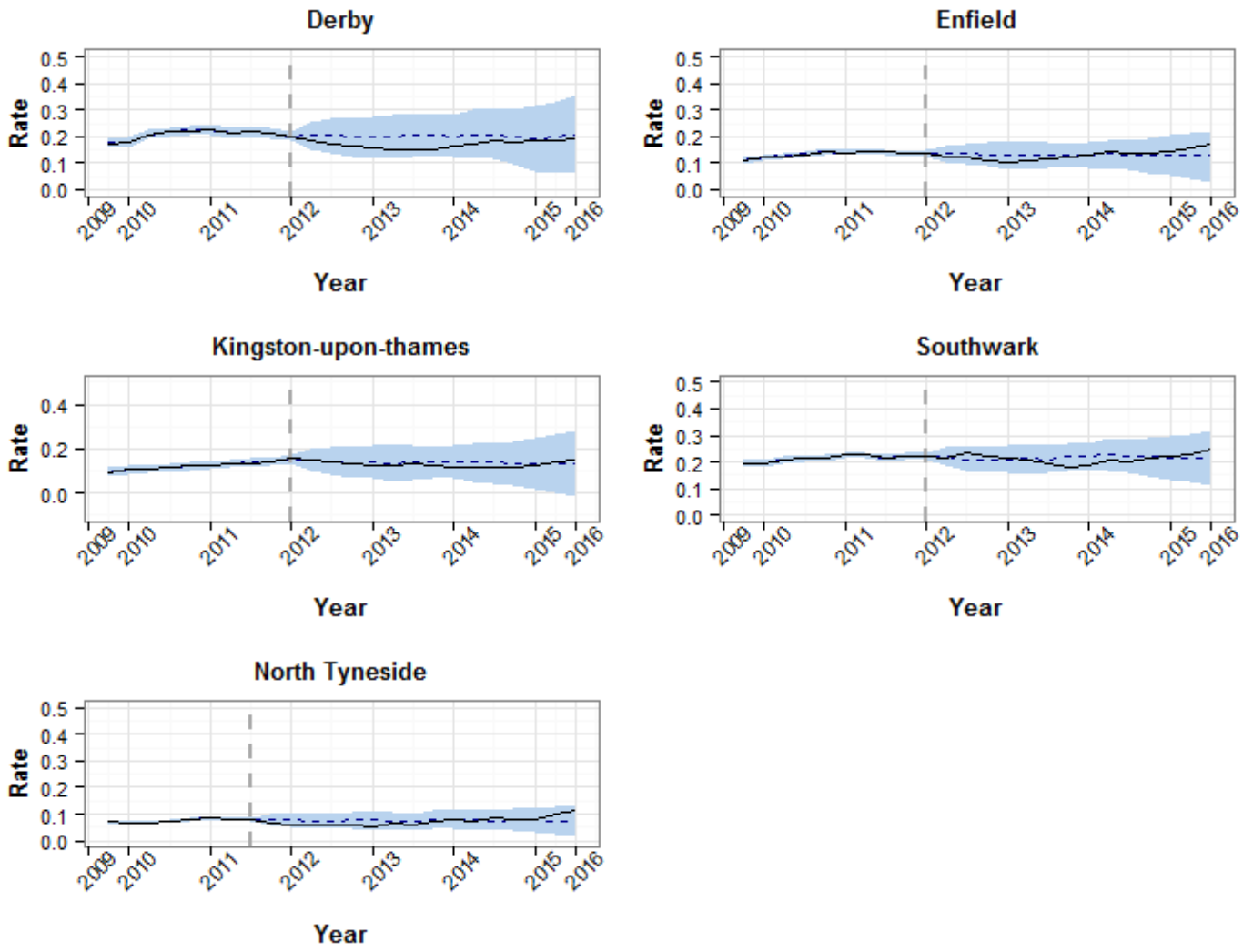


**Figure S1b. Measured (solid line) and modelled, synthetic (dotted line) time series for alcohol-related reported sexual crime rates in the areas with the intervention. Blue areas represent 95% Bayesian Credible Intervals.**

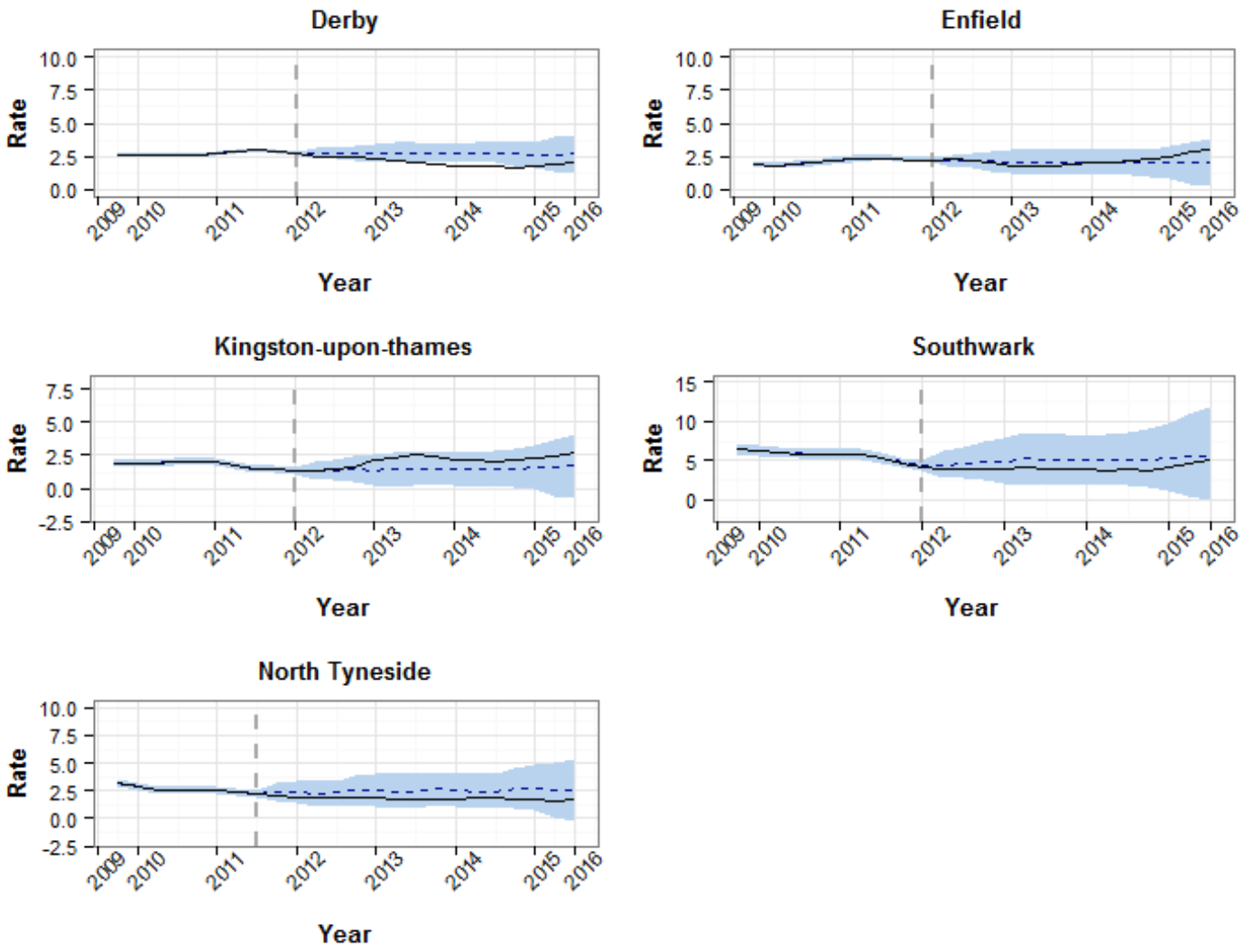


**Figure S1c. Measured (solid line) and modelled, synthetic (dotted line) time series for anti-social behaviour rates in the areas with the intervention. Blue areas represent 95% Bayesian Credible Intervals.**

**OVERVIEW POSTERIOR SUMMARIES ALL OUTCOMES**

***INTERVENTION AREAS***

**Table S2a.** Posterior summaries of relative intervention effect and 95% credible intervals **alcohol-related hospital admissions.**

| **Local Area** | **Posterior 2011-15 causal effect of change in licensing policy** | **95% credible interval** | **Posterior tail-area probability** | **Posterior probability of causal effect** |
|---|---|---|---|---|
| Kingston-upon-Thames | -10.4% | -22.3%:1.1% | 0.035 | 96% |
| Enfield | -11.3% | -31.2%:7.2% | 0.114 | 89% |
| Derby | -4.4% | -21.4% : 10.3% | 0.284 | 72% |
| Southwark | -1.4% | -16.6% : 14.0% | 0.416 | 58% |
| North Tyneside(*) | -2.3% | -18.1% : 12.9% | 0.375 | 62% |
| **Random-effects Meta-analysis (**)** | **Summary effect** | **Summary 95% CI** | **P-value** | **Causal effect** |
| **Summary** | **-6.3%** | **-12.8% : 0.2%** | **0.06** | **94%** |

*: Note that data indicate that 'intervention' was initiated about 6 months earlier. **: Test for heterogeneity $I^2$ = 0.0% (P-value=0.885)

**Table S2b.** Posterior summaries of relative intervention effect and 95% credible intervals **alcohol-related violent crimes.**

| | **2009-2015** | | | | **2009- (mid)2013** | | |
|---|---|---|---|---|---|---|---|
| **Local Area** | **Posterior effect of change in licensing policy** | **95% credible interval** | **Posterior tail-area probability** | **Posterior probability of causal effect** | **Posterior effect of change in licensing policy** | **95% credible interval** | **Posterior probability of causal effect** |
| Kingston-upon-Thames | -5.9% | -17.4%:6.1% | 0.151 | 85% | -1.3% | -10.2%:8.2% | 63% |
| Enfield | +4.9% | -7.4%:17.2% | 0.209 | 79% | -3.5% | -13.0%:6.5% | 77% |
| Derby | -17.9% | -39.3%:3.9% | 0.049 | 95% | -12.2% | -28.3%:4.3% | 93% |
| Southwark | -7.9% | -41.9%:26.8% | 0.315 | 69% | -9.3% | -34.7%:16.4% | 78% |
| North Tyneside(*) | -12.3% | -50.0%:27.1% | 0.243 | 76% | -16.7% | -45.5%:13.5% | 88% |
| **Random-effects Meta-analysis (**)** | **Summary effect** | **Summary 95% CI** | **P-value** | **Causal effect** | **Summary effect** | **Summary 95% CI** | **Causal effect** |
| **Summary** | **-4.4 %** | **-13.7% : 4.9%** | **0.355** | **65%** | **-4.6%** | **-10.7%:1.4%** | **87%** |

*: Note that data indicate that 'intervention' was initiated about 6 months earlier. **: Test for heterogeneity $I^2$ = 20.15% (P-value=0.425)

**Table S2c.** Posterior summaries of relative intervention effect and 95% credible intervals alcohol-related sex crimes**.**

| | 2009-2015 | | | | 2009- (mid)2013 | | |
|---|---|---|---|---|---|---|---|
| **Local Area** | **Posterior effect of change in licensing policy** | **95% credible interval** | **Posterior tail-area probability** | **Posterior probability of causal effect** | **Posterior effect of change in licensing policy** | **95% credible interval** | **Posterior probability of causal effect** |
| Kingston-upon-Thames | -6.7% | -54.0%,41.7% | 0.350 | 65% | -3.5% | -46.6%,39.5% | 58% |
| Enfield | -0.1% | -33.1%,33.0% | 0.481 | 52% | -12.9% | -43.8%,18.0% | 83% |
| Derby | -15.5% | -48.1%,17.1% | 0.148 | 85% | -18.9% | -50.2%,12.5% | 90% |
| Southwark | -2.0% | -22.6%, 18.7% | 0.398 | 60% | 1.0% | -19.4%,21.4% | 54% |
| North Tyneside(*) | -3.6% | -38.1%,30.9% | 0.397 | 60% | -19.1% | -52.2%,14.1% | 89% |
| **Random-effects Meta-analysis (**)** | **Summary effect** | **Summary 95% CI** | **P-value** | **Causal effect** | **Summary effect** | **Summary 95% CI** | **Causal effect** |
| **Summary** | **-4.7%** | **-18.9%, 9.5%** | **0.520** | **50%** | **-8.4%** | **-21.4%,4.6%** | **80%** |

*: Note that data indicate that 'intervention' was initiated about 6 months earlier.

**Table S2d.** Posterior summaries of relative intervention effect and 95% credible intervals **anti-social behaviour.**

| | **2009-2015** | | | | **2009- (mid)2013** | | |
|---|---|---|---|---|---|---|---|
| **Local Area** | **Posterior effect of change in licensing policy** | **95% credible interval** | **Posterior tail-area probability** | **Posterior probability of causal effect** | **Posterior effect of change in licensing policy** | **95% credible interval** | **Posterior probability of causal effect** |
| Kingston-upon-Thames | 44% | -31%, 117% | 0.103 | 90% | 37% | -27%,98% | 89% |
| Enfield | 6.4% | -33%, 46% | 0.350 | 65% | -6.2% | -38%,25% | 68% |
| Derby | -25% | -49%, -1.6% | 0.020 | 98% | -16% | -34%,3% | 96% |
| Southwark | -21% | -76%, 33% | 0.198 | 80% | -20% | -66%,25% | 83% |
| North Tyneside(*) | -27% | -76%, 21% | 0.114 | 89% | -22% | -61%,17% | 89% |
| **Random-effects Meta-analysis (**)** | **Summary effect** | **Summary 95% CI** | **P-value** | **Causal effect** | **Summary effect** | **Summary 95% CI** | **Causal effect** |
| **Summary** | **-14.3** | **-32.9%, 4.4%** | **0.133** | **87%** | **-12.6%** | **-26.4%,1.3%** | **93%** |

*: Note that data indicate that 'intervention' was initiated about 6 months earlier.

**: Test for heterogeneity $I^2$ = 8.34% (P-value=0.329)

## SENSITIVITY ANALYSES

*ALTERNATIVE BAYESIAN PRIORS*

### Table S3a. Posterior summaries of relative intervention effect and 95% credible intervals alcohol-related hospital admission rates.

**Alternative priors**: Stricter priors with sigma prior and sigma guess 1% of sample sd (proposed for stable time series), upper limit for sigma at 100% of sample sd, and prior explained variance set at 90%.

| **Local Area** | **Posterior 2011-15 causal effect of change in licensing policy** | **95% credible interval** | **Posterior tail-area probability** | **Posterior probability of causal effect** |
|---|---|---|---|---|
| Kingston-upon-Thames | -10.5% | -20.7%:-0.5% | 0.021 | 98% |
| Enfield | -11.2% | -28.4%:4.6% | 0.083 | 92% |
| Derby | -4.1% | -19.0%:8.1% | 0.278 | 72% |
| Southwark | -1.3% | -14.4%:6.6% | 0.410 | 59% |
| North Tyneside | -2.2% | -15.6%:10.9% | 0.362 | 64% |
| **Random-effects Meta-analysis** | **Summary effect** | **Summary 95% CI** | **P-value** | **Causal effect** |
| **Summary** | **-6.1%** | **-11.7%:-0.6%** | **0.031** | **97%** |

**Table S3b. Posterior summaries of relative intervention effect and 95% credible intervals alcohol-related hospital admission rates.**

**Alternative priors**: Uninformative priors with sigma prior and sigma guess set to sample standard deviation and upper limit for sigma set to 10*sd, sigma priors for betas set to 10*sd sample, and prior explained variance set at 50%.

| **Local Area** | **Posterior 2011-15 causal effect of change in licensing policy** | **95% credible interval** | **Posterior tail-area probability** | **Posterior probability of causal effect** |
|---|---|---|---|---|
| Derby | -3.3% | -54.1%:46.8% | 0.448 | 55% |
| Enfield | -8.8% | -71.1%:53.1% | 0.385 | 61% |
| Kingston-upon-Thames | -11.8% | -46.6%:23.0% | 0.241 | 76% |
| Southwark | -1.5% | -54.5%:51.5% | 0.475 | 52% |
| North Tyneside | -3.5% | -55.5%:47.5% | 0.446 | 55% |
| **Random-effects Meta-analysis** | **Summary effect** | **Summary 95% CI** | **P-value** | **Causal effect** |
| **Summary** | **-6.8%** | **-28.0%:14.3%** | **0.527** | **47%** |

**Table S3c. Posterior summaries of relative intervention effect and 95% credible intervals alcohol-related reported violent crime rates.**

**Alternative priors**: Stricter priors with sigma prior and sigma guess 1% of sample sd (proposed for stable time series), upper limit for sigma at 100% of sample sd, and prior explained variance set at 90%.

| **Local Area** | **Posterior 2011-14 causal effect of change in licensing policy** | **95% credible interval** | **Posterior tail-area probability** | **Posterior probability of causal effect** |
|---|---|---|---|---|
| Kingston-upon-Thames | -5.6% | -15.6%:5.0% | 0.141 | 86% |
| Enfield | +4.9% | -5.7%:15.7% | 0.176 | 82% |
| Derby | -17.5% | -35.2%:0.8% | 0.029 | 97% |
| Southwark | -6.8% | -36.7%:22.2% | 0.314 | 69% |
| North Tyneside(*) | -12.6% | -44.2%:21.2% | 0.203 | 80% |
| **Random-effects Meta-analysis (***)** | **Summary effect** | **Summary 95% CI** | **P-value** | **Causal effect** |
| **Summary** | **-4.8%** | **-13.9%:4.4%** | **0.306** | **69%** |

**Table S3d. Posterior summaries of relative intervention effect and 95% credible intervals alcohol-related reported violent crime rates.**

**Alternative priors**: Uninformative priors with sigma prior and sigma guess set to sample standard deviation and upper limit for sigma set to 10*sd, sigma priors for betas set to 10*sd sample, and prior explained variance set at 50%.

| **Local Area** | **Posterior 2011-14 causal effect of change in licensing policy** | **95% credible interval** | **Posterior tail-area probability** | **Posterior probability of causal effect** |
|---|---|---|---|---|
| Derby | -18.3% | -97.1%:59.9% | 0.316 | 68% |
| Enfield | -0.1% | -35.5%:35.5% | 0.499 | 50% |
| Kingston-upon-Thames | -11.3% | -45.5%:23.4% | 0.252 | 75% |
| Southwark | -21.4% | -110.6%:68.4% | 0.311 | 69% |
| North Tyneside(*) | -11.0% | -122%:100% | 0.419 | 58% |
| **Random-effects Meta-analysis (***)** | **Summary effect** | **Summary 95% CI** | **P-value** | **Causal effect** |
| **Summary** | **-8.0%** | **-30.5%:14.4%** | **0.483** | **52%** |

## CONTROL AREAS CONTRIBUTING TO 'SYNTHETIC CONTROL' TIMESERIES

**Table S4a. Areas contributing most to synthetic control (i.e. top-5 based on inclusion probability)**

| **Alcohol-related hospital admissions** | | | | | |
|---|---|---|---|---|---|
| **Highest inclusion probability** | 1st | 2nd | 3rd | 4th | 5th |
| **Kingston-upon-Thames** | Stevenage | Craven | Hambleton | Cannock Chase | Sefton |
| **Enfield** | Ribble Valley | Tunbridge Wells | Rother | Fareham | South Staffordshire |
| **Derby** | Ribble Valley | Broxtowe | South Holland | North Warwickshire | Maidstone |
| **Southwark** | Taunton Deane | Babergh | Thurrock | South Bucks | Ipswich |
| **North Tyneside** | Rother | Ribble Valley | Tunbridge Wells | Torridge | High Peak |

**Table S4b. Areas contributing most to synthetic control (i.e. top-5 based on inclusion probability)**

| **Alcohol-related violent crime rates** | | | | | |
|---|---|---|---|---|---|
| **Highest inclusion probability** | 1st | 2nd | 3rd | 4th | 5th |
| **Kingston-upon-Thames** | Sefton | Lewes | Harlow | Basildon | Ipswich |
| **Enfield** | Nuneaton and Bedworth | South Bucks | Three rivers | North East Lincolnshire | Bracknell Forest |
| **Derby** | Newark and Sherwood | North East Lincolnshire | Stevenage | South Derbyshire | Mid Sussex |
| **Southwark** | South Bucks | East Hampshire | Bracknell Forest | Nuneaton and Bedworth | Basildon |
| **North Tyneside** | Hambleton | Waverley | Three Rivers | Gateshead | Barnsley |

**Table S4c. Areas contributing most to synthetic control (i.e. top-5 based on inclusion probability)**

| **Alcohol-related sexual crime rates** | | | | | |
|---|---|---|---|---|---|
| **Highest inclusion probability** | 1st | 2nd | 3rd | 4th | 5th |
| **Kingston-upon-Thames** | Hyndburn | South Bucks | Runnymede | South Norfolk | Sefton |
| **Enfield** | South Bucks | Fareham | North Somerset | Chichester | St Albans |
| **Derby** | High Peak | Braintree | Hillingdon | Stevenage | Blackburn with Darwen |
| **Southwark** | Hyndburn | Epsom and Ewell | Gateshead | Swale | Rother |
| **North Tyneside** | Barrow in Furness | Hillingdon | Rother | Mole Valley | Chelmsford |

**Table S4d. Areas contributing most to synthetic control (i.e. top-5 based on inclusion probability)**

| **Anti social behaviour** | | | | | |
|---|---|---|---|---|---|
| **Highest inclusion probability** | 1st | 2nd | 3rd | 4th | 5th |
| **Kingston-upon-Thames** | Vale of White Horse | Rotherham | Maidstone | East Northamptonshire | St. Helens |
| **Enfield** | North East Lincolnshire | Epsom and Ewell | Tonbridge and Malling | Blackburn with Darwin | Basildon |
| **Derby** | South Bucks | Maidstone | Hillingdon | Tunbridge Wells | Hyndburn |
| **Southwark** | East Northamptonshire | Crawley | Rotherham | Chorley | Hambleton |
| **North Tyneside** | Rother | North Somerset | Rotherham | Stevenage | Hambleton |

**META-ANALYTIC RESULTS OF VALIDATION ANALYSES**

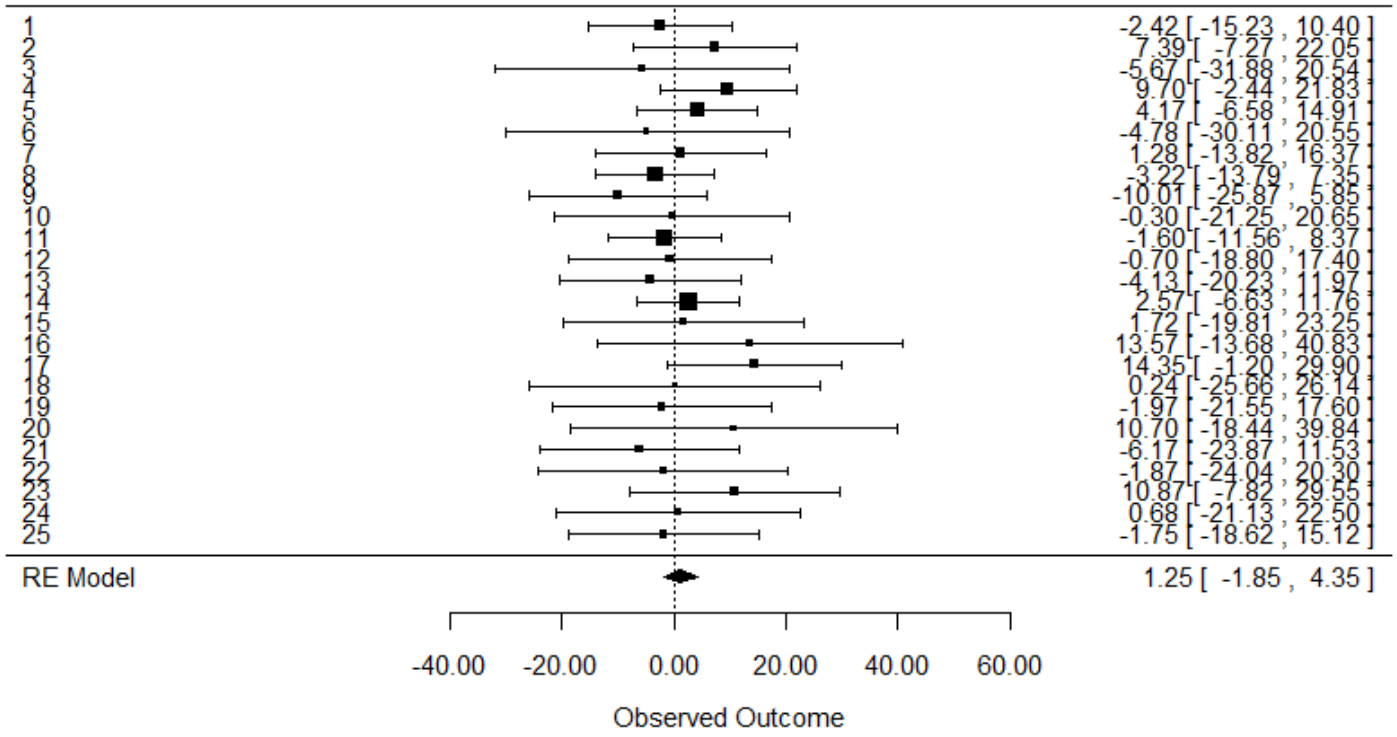


**Figure S2a.** Posterior summaries of relative intervention effect (in %) and 95% credible intervals **alcohol-related hospital admissions** for 25 randomly selected control areas (i.e. where alcohol licensing policies were not introduced)

(Years 2011 – 2015)

(Years 2011 – 2013)

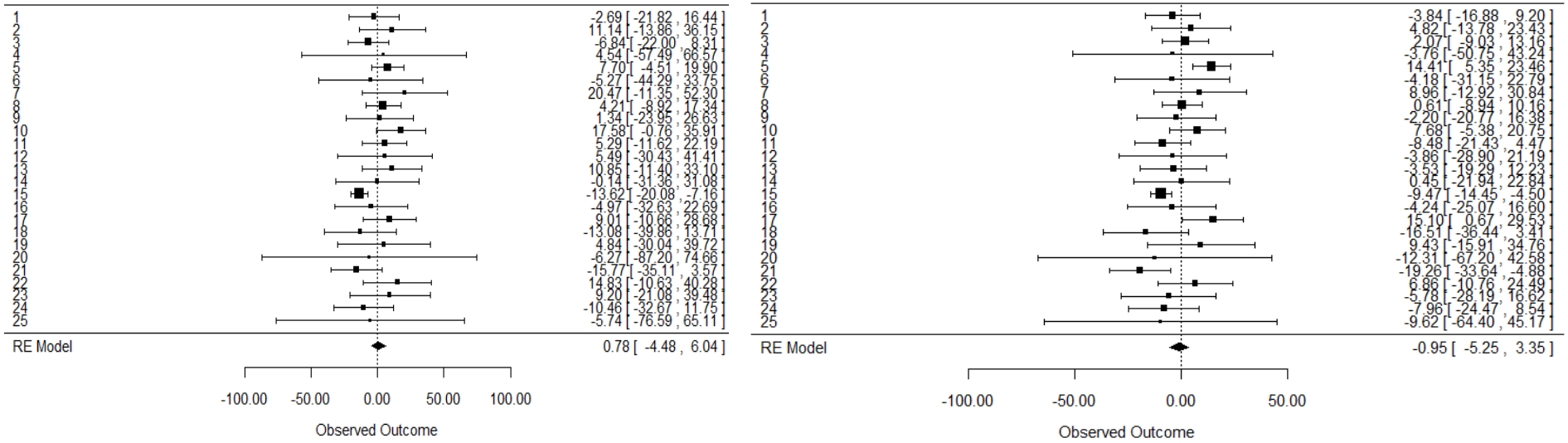


**Figure S2b.** Posterior summaries of relative intervention effect (in %) and 95% credible intervals alcohol-related violent crimes for 25 randomly selected control areas (i.e. where alcohol licensing policies were not introduced)

(Years 2011 – 2015)

(Years 2011 – 2013)

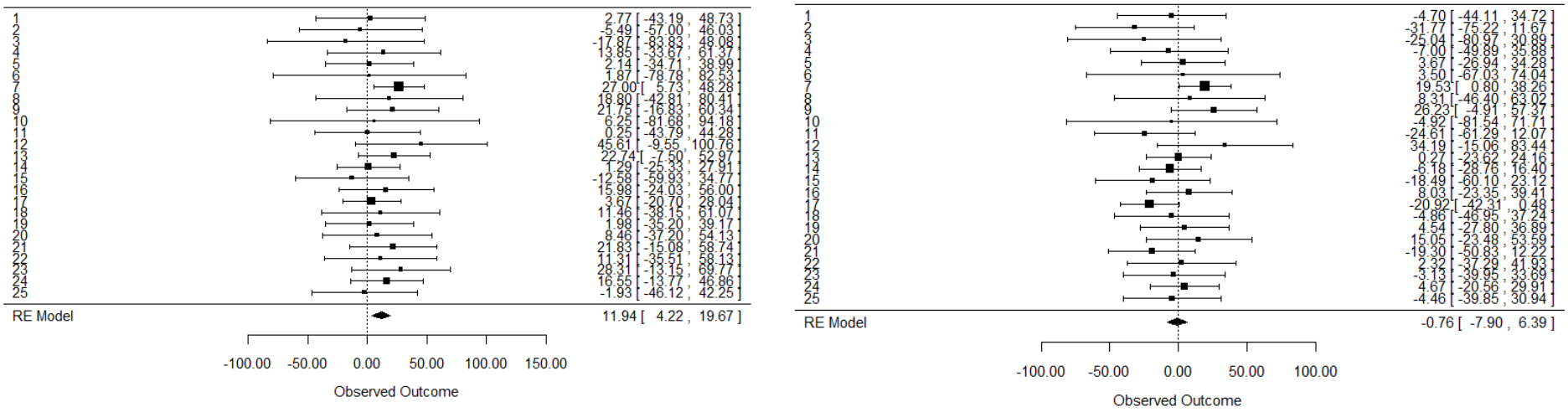


**Figure S2c.** Posterior summaries of relative intervention effect (in %) and 95% credible intervals **alcohol-related sex crimes** for 25 randomly selected control areas (i.e. where alcohol licensing policies were not introduced)

(Years 2011 – 2015)

(Years 2011 – 2013)

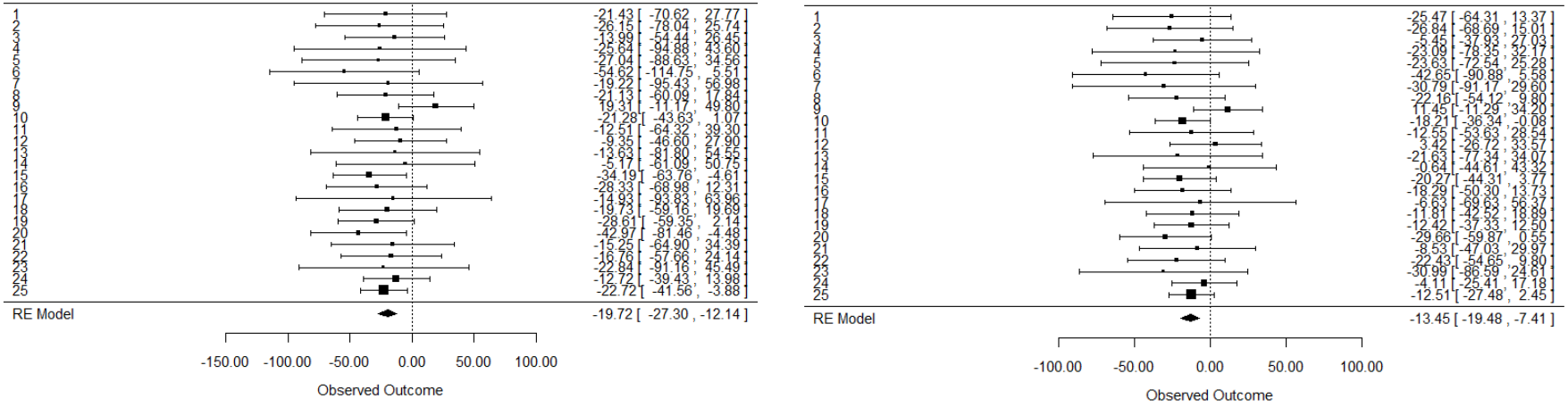


**Figure S2d.** Posterior summaries of relative intervention effect (in %) and 95% credible intervals **anti-social behaviour** for 10 randomly selected control areas (i.e. where alcohol licensing policies were not introduced)